

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
 SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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100

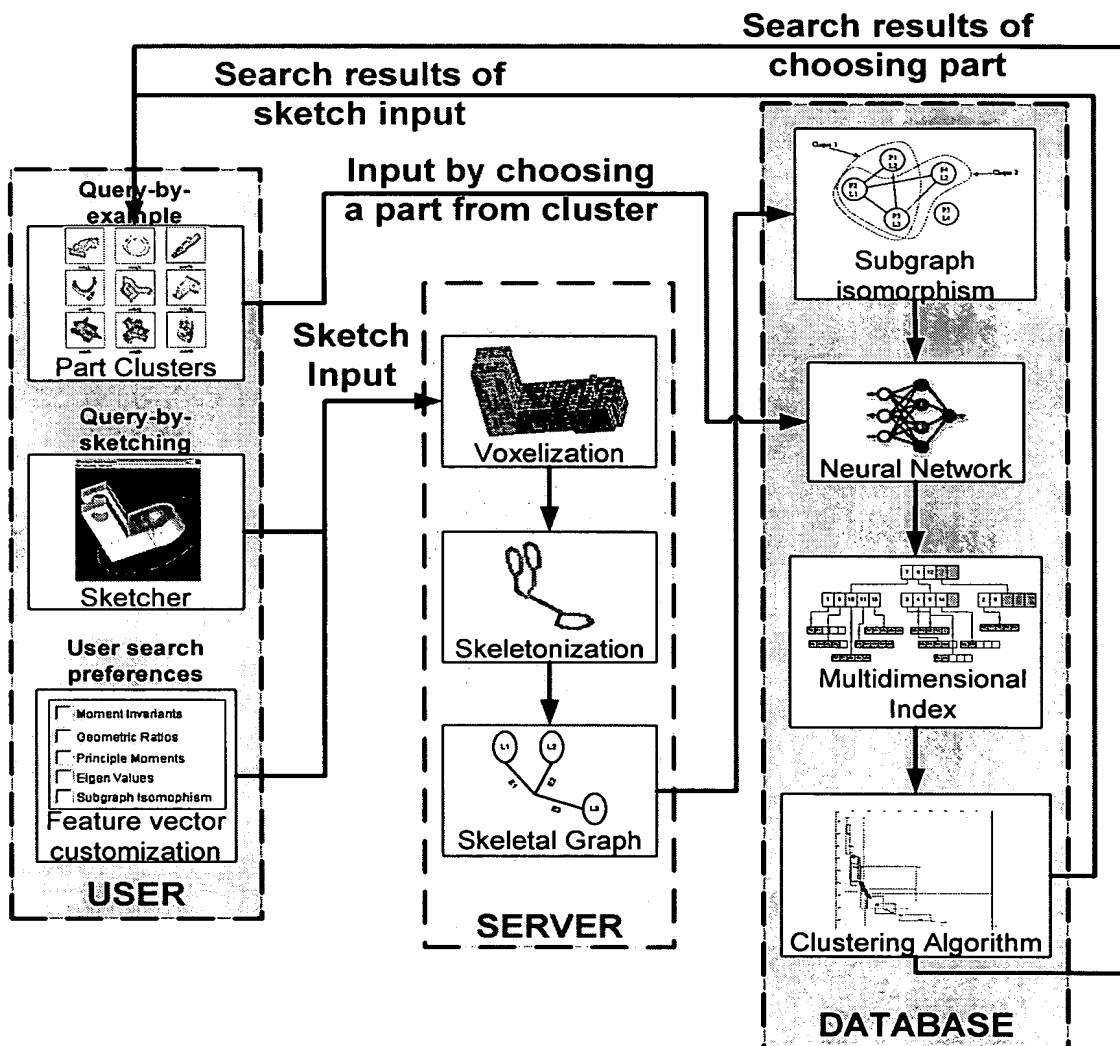


FIG. 1

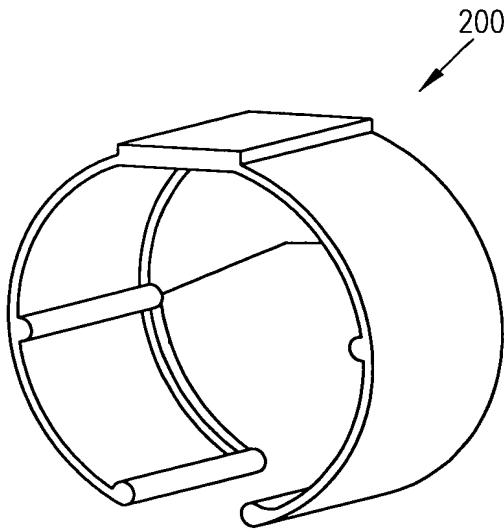


FIG. 2A

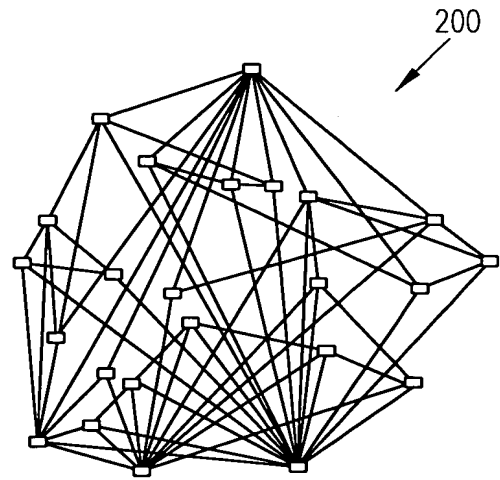


FIG. 2B

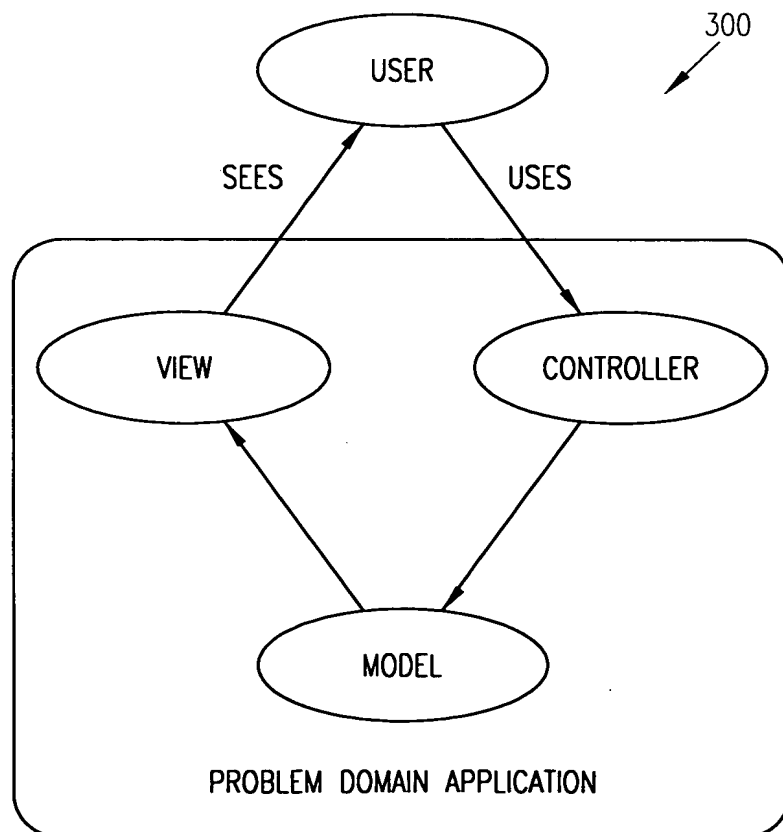


FIG. 3

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400

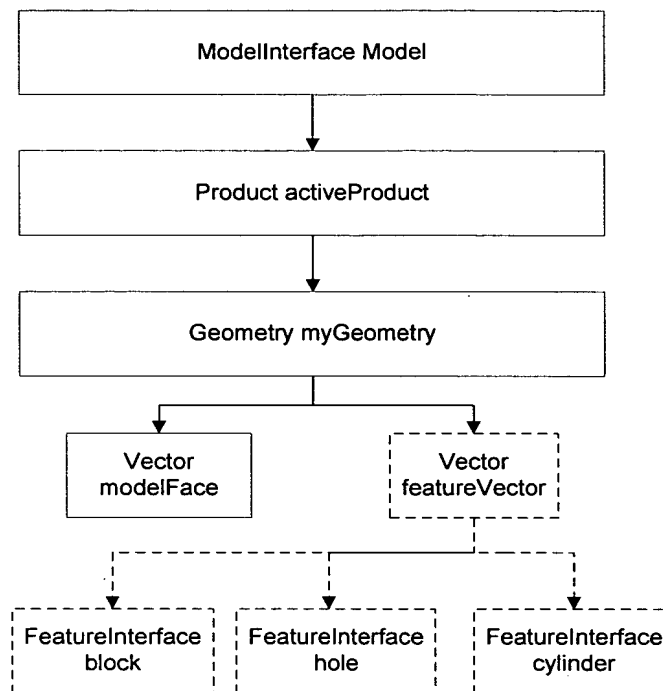


FIG. 4

500

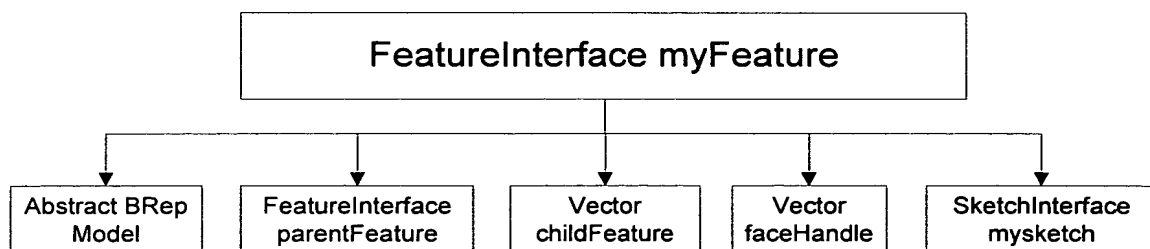


FIG. 5

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600

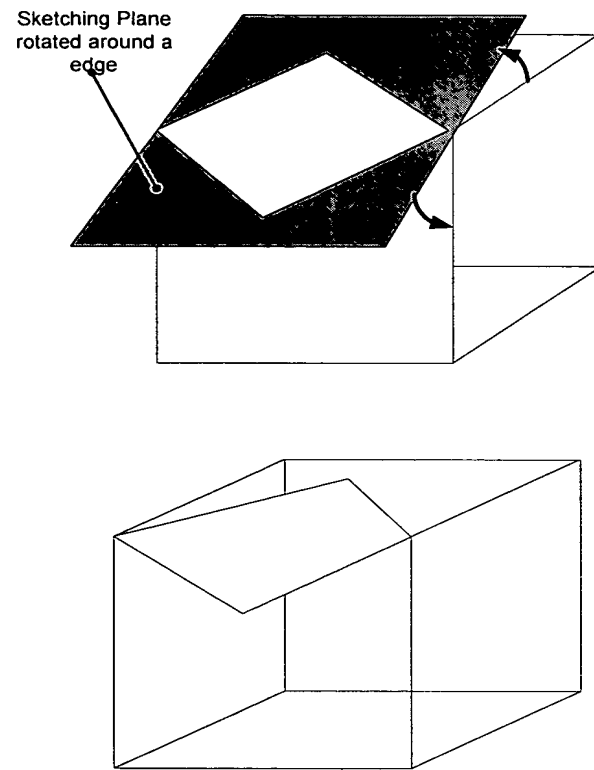


FIG. 6

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700

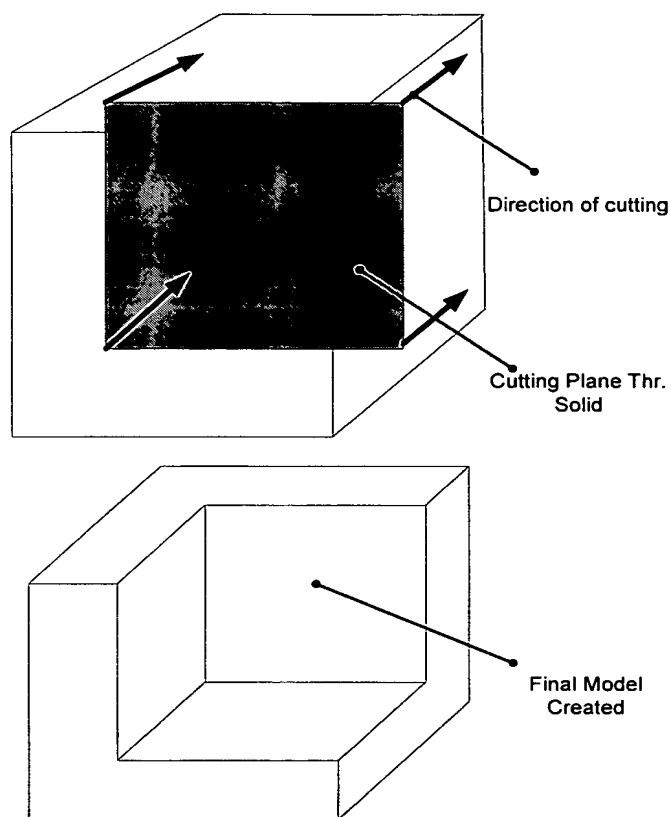


FIG. 7

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800

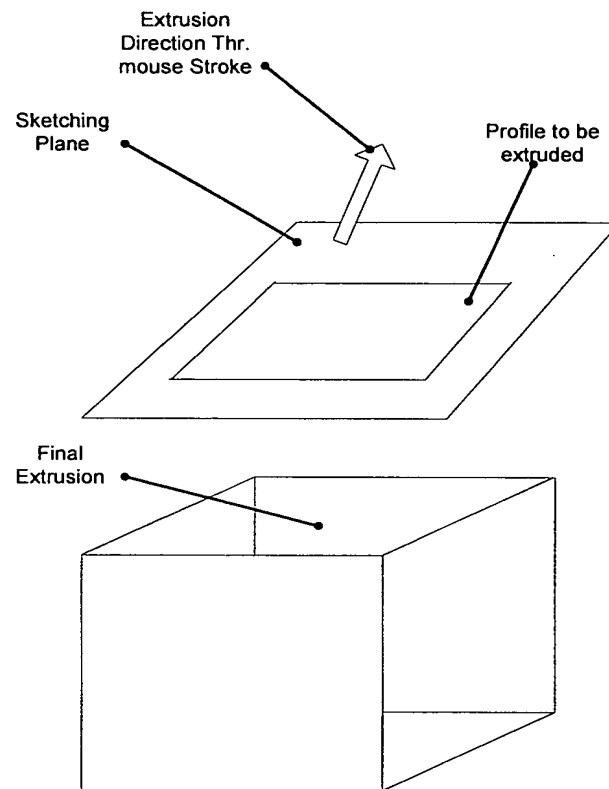


FIG. 8

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900

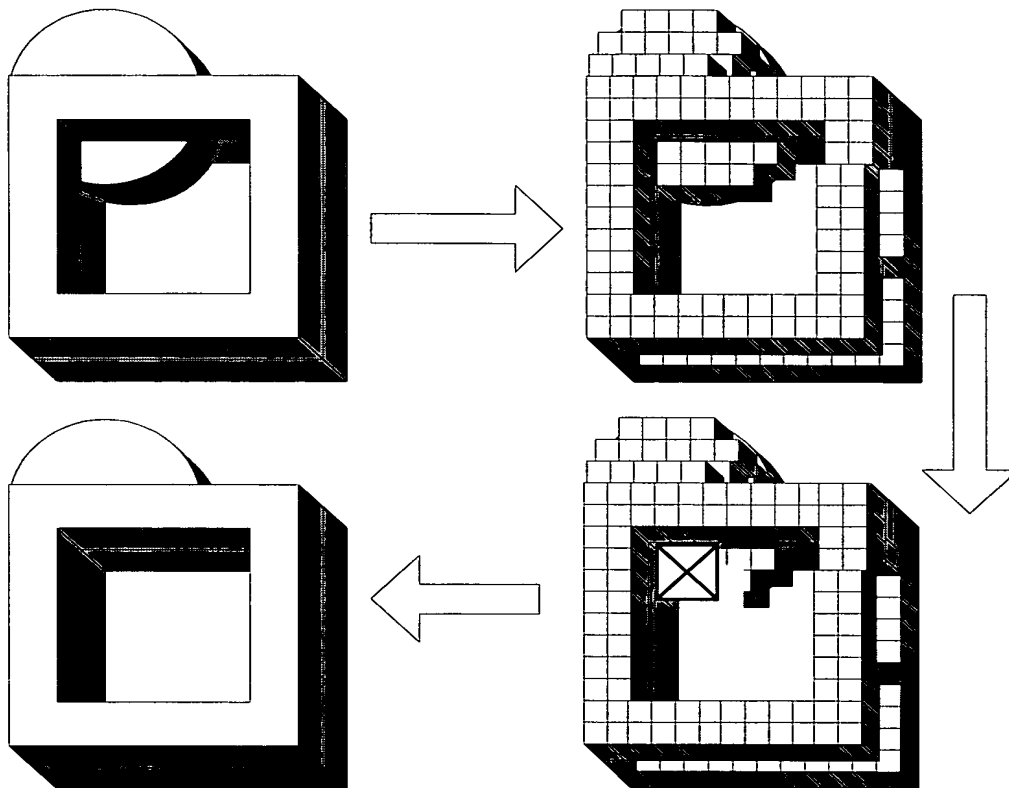


FIG. 9

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

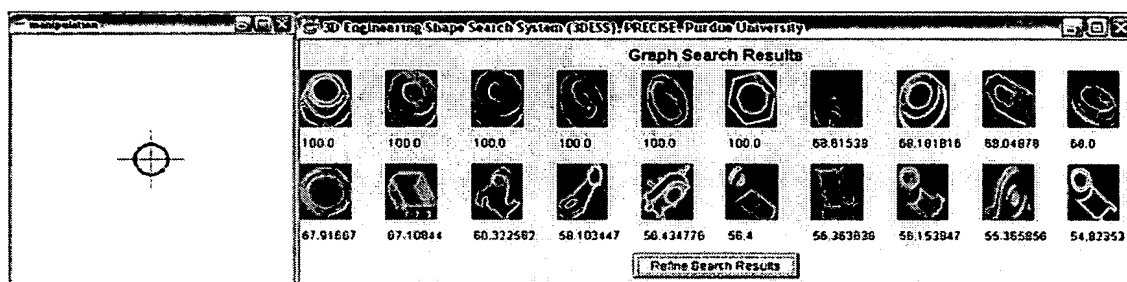
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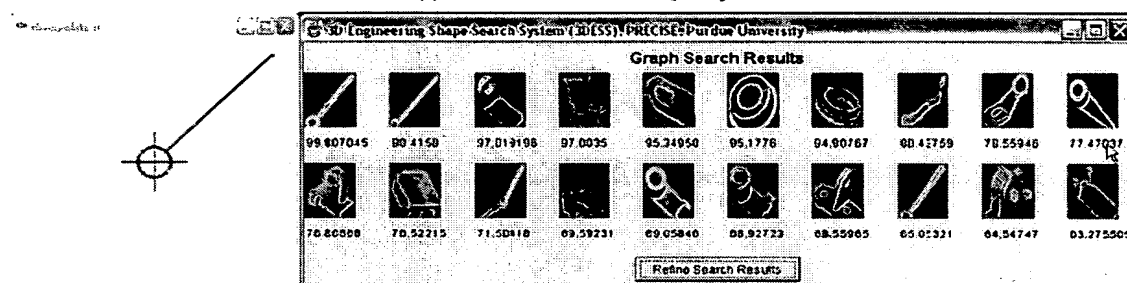
1000



Query

Search Results

(i) Initial Skeleton Query



Query

Search Results

(ii) Modified Skeleton Query

FIG. 10

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1100

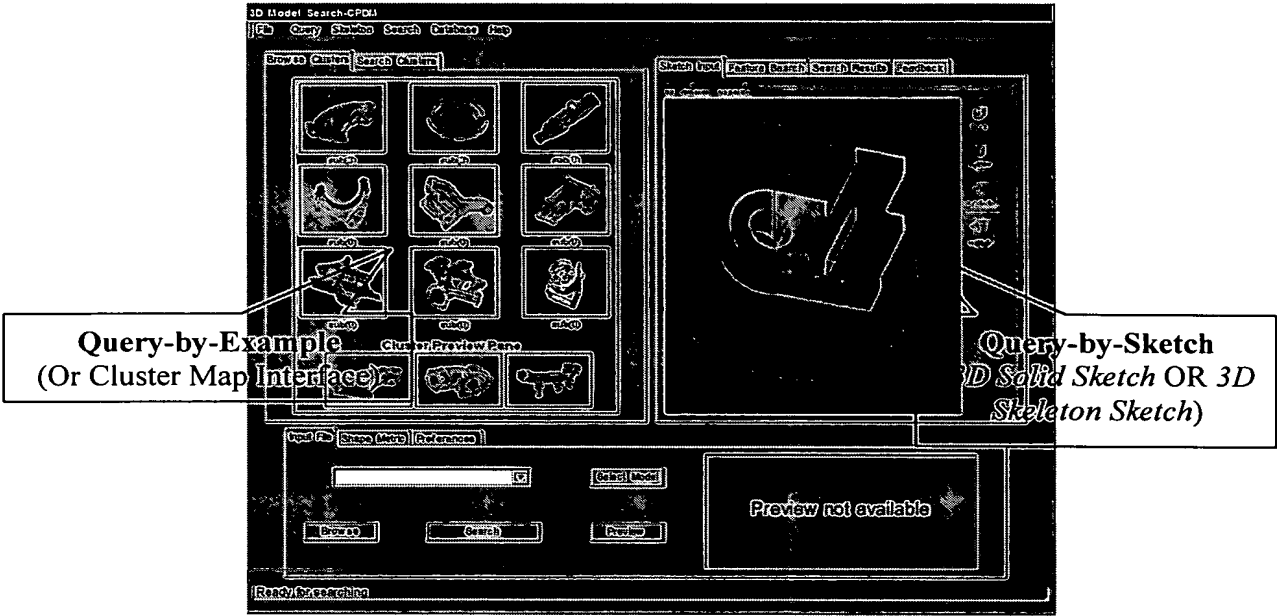


FIG. 11

1200

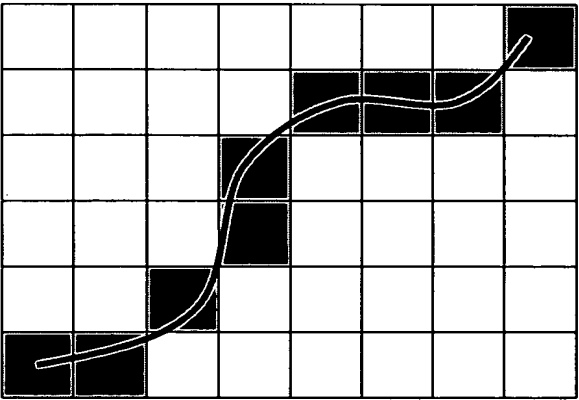


FIG. 12

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

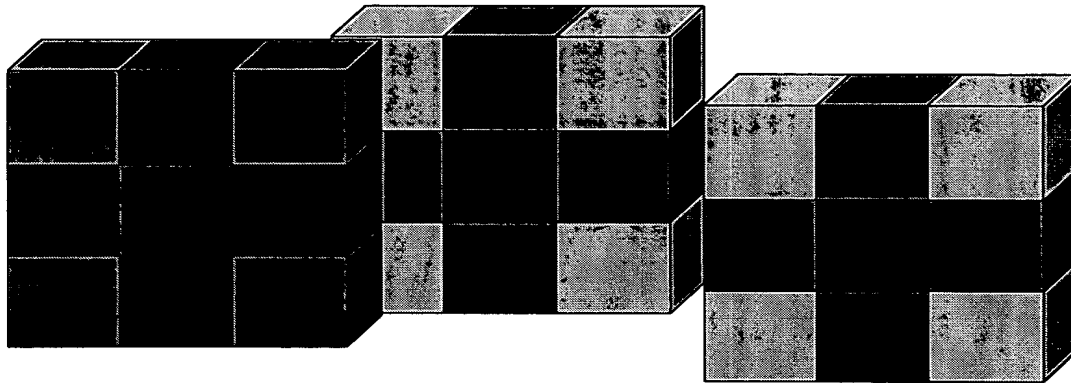
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1300






-  6 neighbors (plane)
-  12 neighbors (edge)
-  18 neighbors (point)

FIG. 13

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1400



```
Read in B-Rep model M
Assign FacelDs F to all faces in M
Assign EdgelDs E to all faces in M
Set voxel size S
Find B-Rep model bounding box
Find discrete bounding box coordinates X, Y ,Z
Create voxel text file T

for i in X in increment of S:
  for j in Y in increment of S:
    for k in Z in increment of S:
      construct voxel v of size S using ACIS
      test intersection of v with M using ACIS
      if v intersects with M:
        store "1" in T
        find faces intersecting with v using ACIS
        find edges intersecting with v using ACIS
        store F and E for all intersecting faces in v
      else:
        store "0" in T
```

FIG. 14

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1500

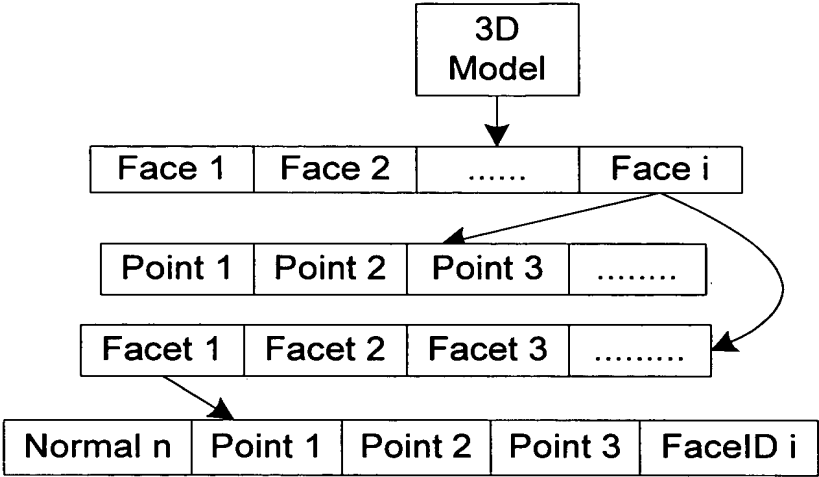


FIG. 15

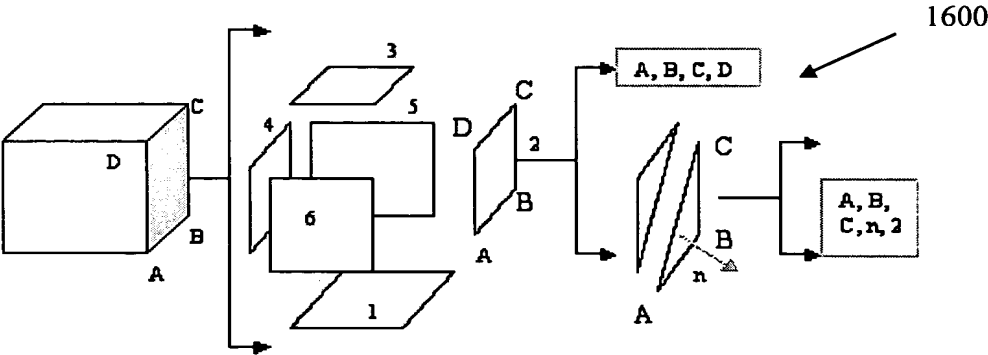


FIG. 16

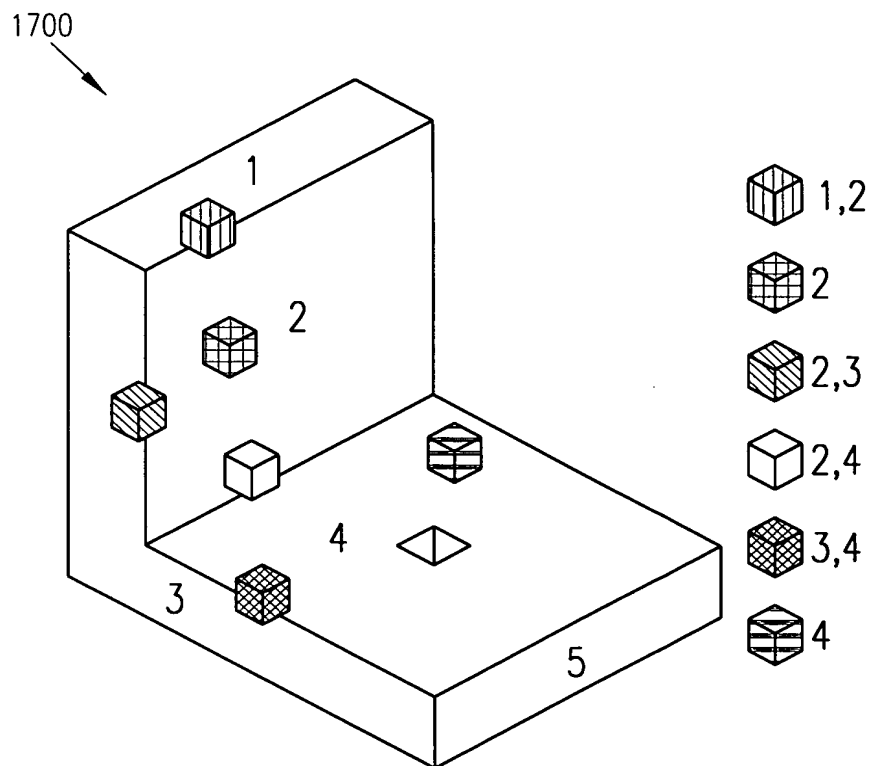


FIG. 17

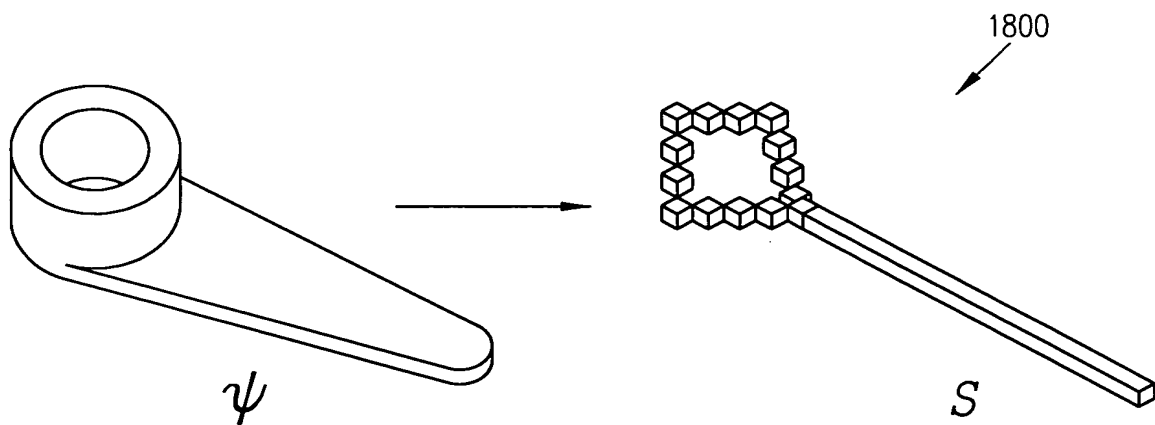


FIG. 18

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1900

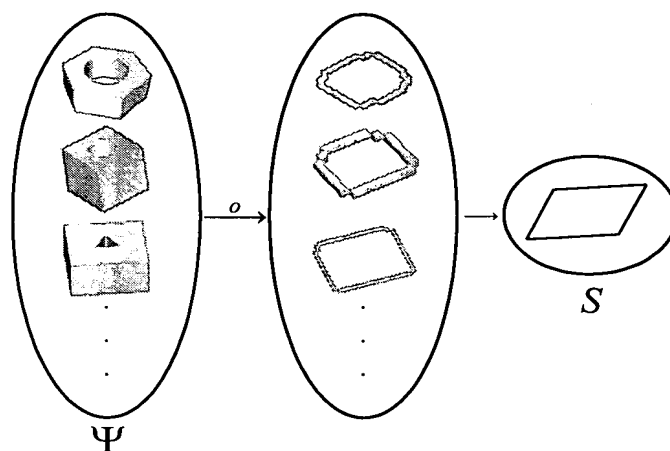


FIG. 19

2000

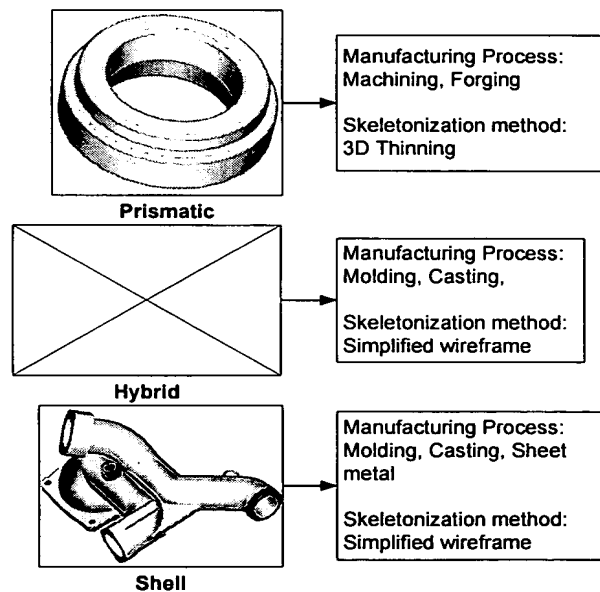


FIG. 20

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2100

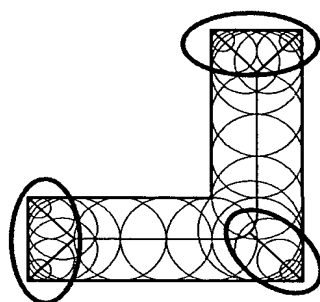


FIG. 21

2200

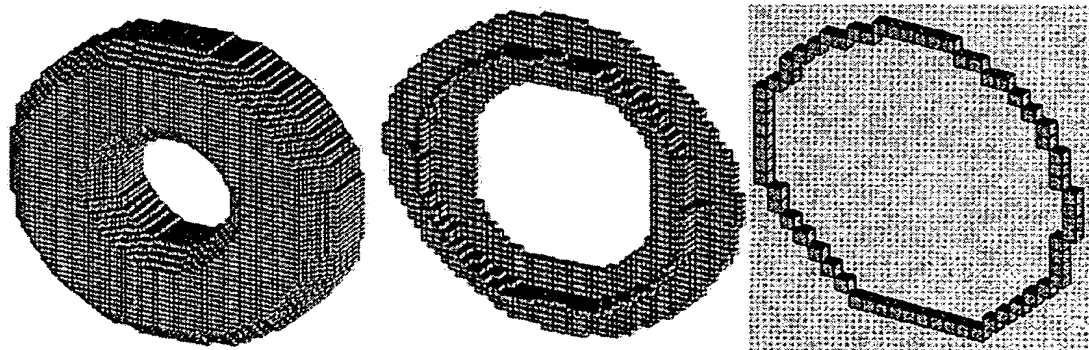


FIG. 22

2300

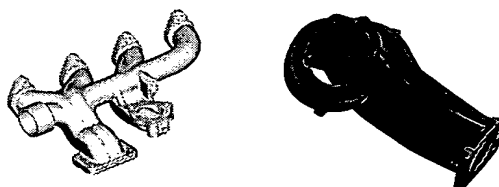


FIG. 23

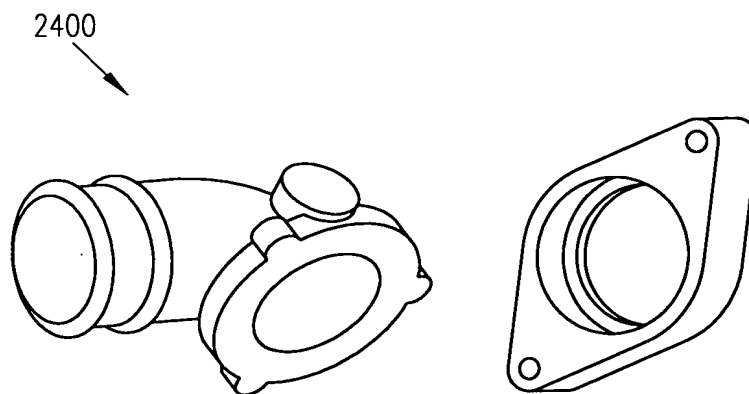


FIG. 24

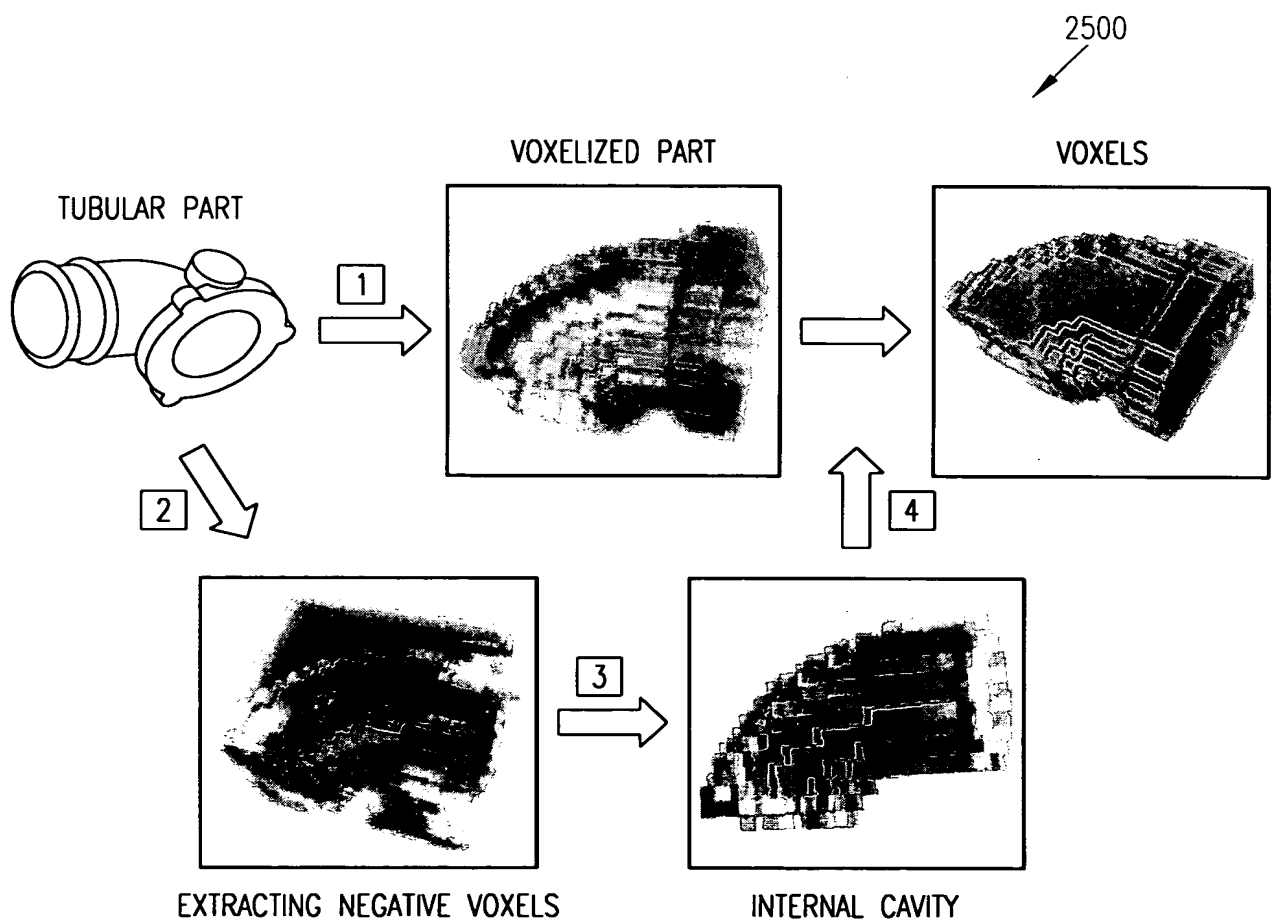


FIG. 25

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

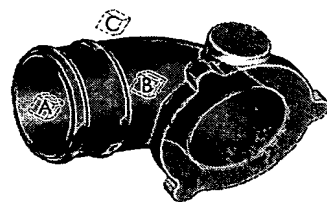
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2600



Center voxel

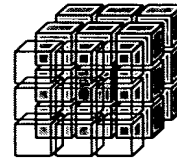


visible direction

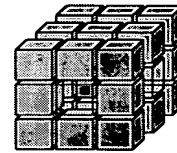


invisible direction

A



B



C

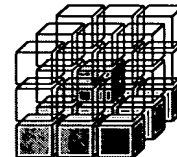


FIG. 26

2700

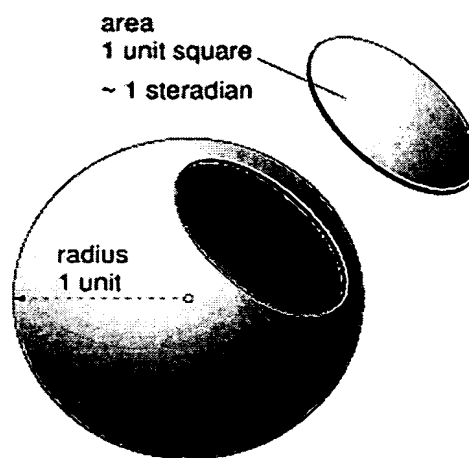


FIG. 27

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2800

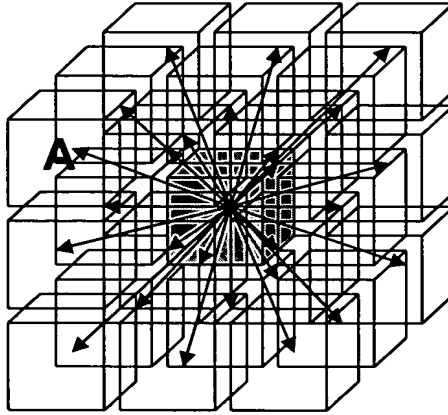


FIG. 28

2900

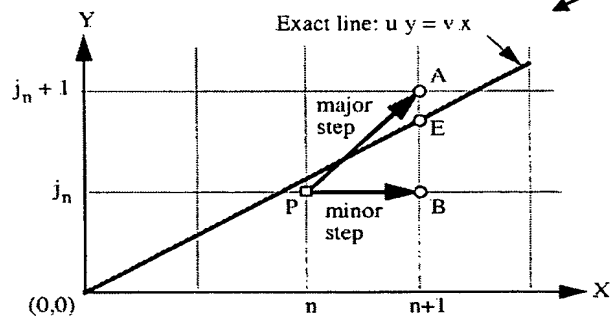


FIG. 29

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SEARCHES ON THREE DIMENSIONAL OBJECTS

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3000

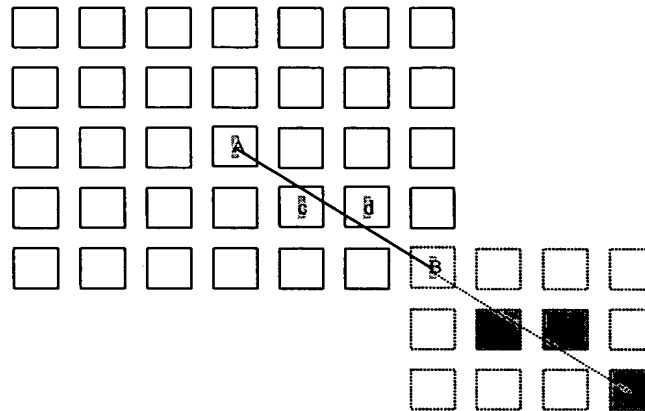


FIG. 30

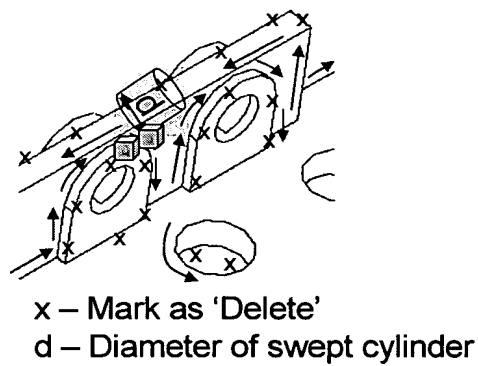
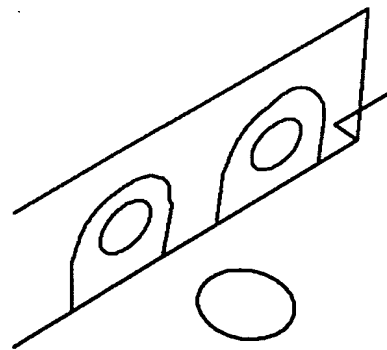


FIG. 31

3100



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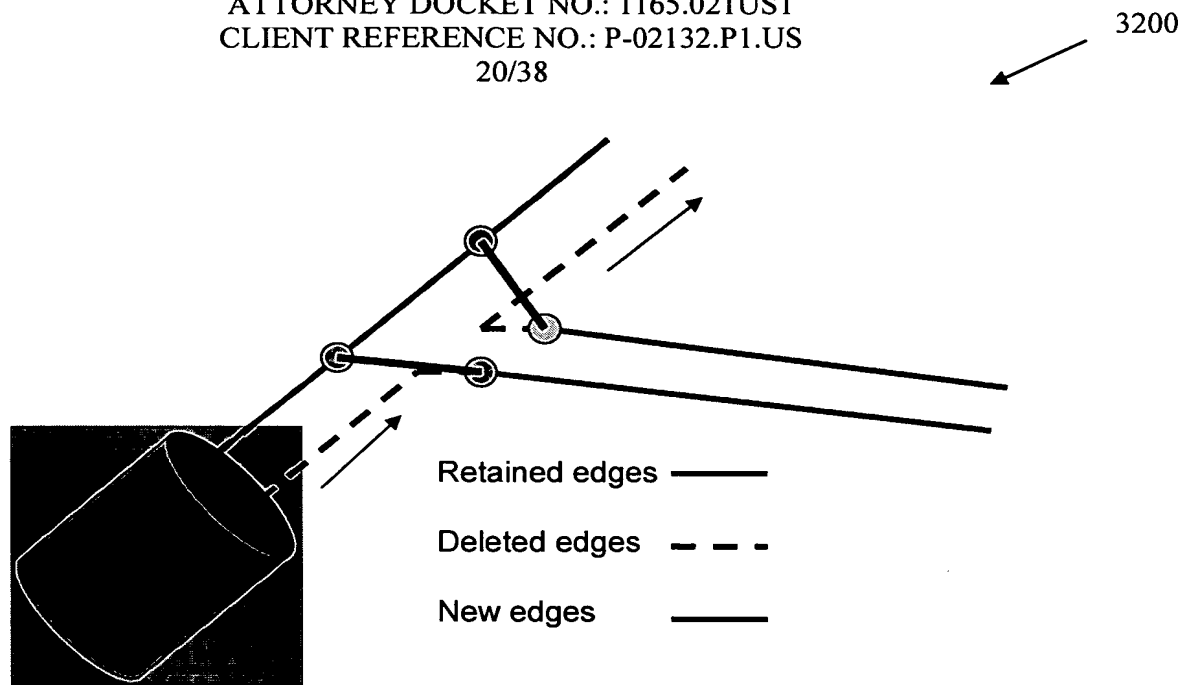


FIG. 32

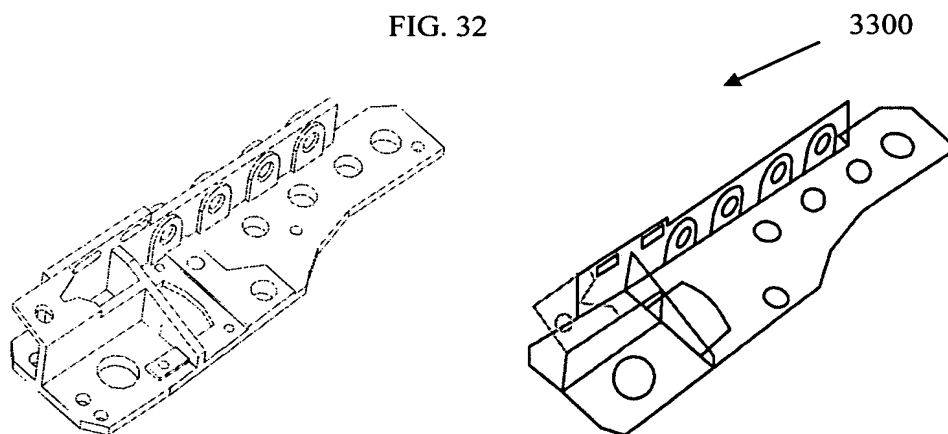


FIG. 33

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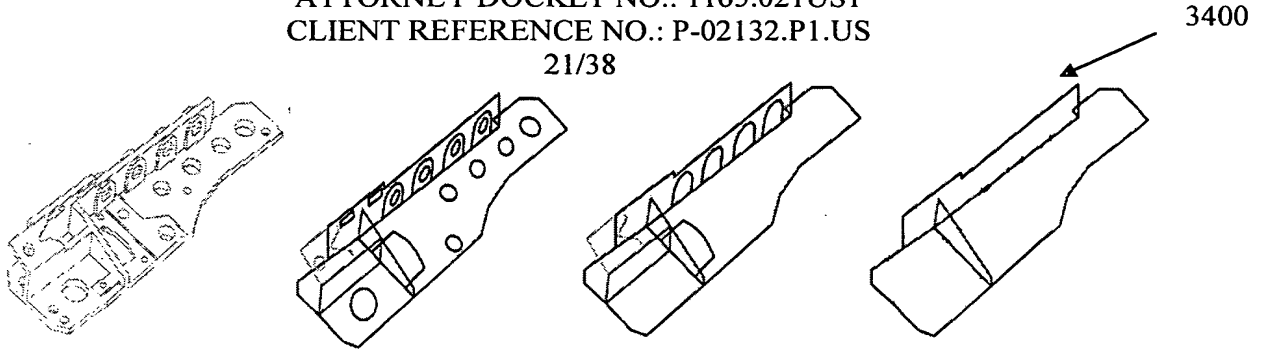


FIG. 34

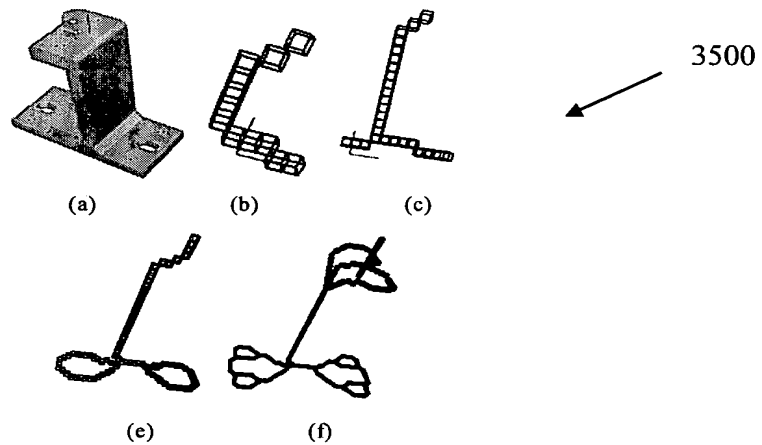


FIG. 35: (a) 3D model, (b) Levels of detail (LOD) for $n = 2$, (c) LOD for $n = 3$, (d) LOD for $n = 4$, (e) LOD for $n = 5$

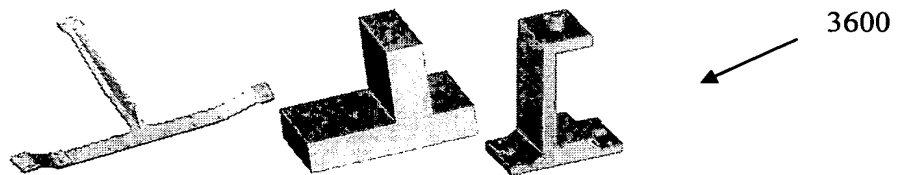


FIG. 36

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3700

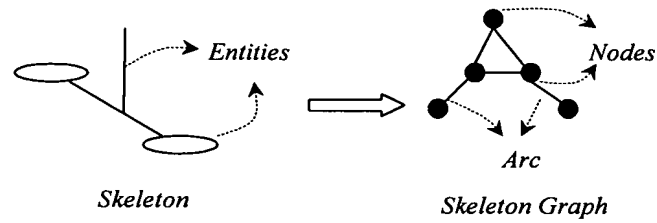
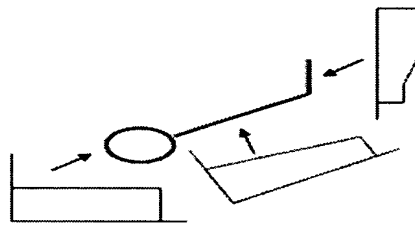
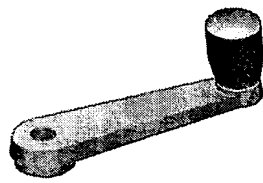
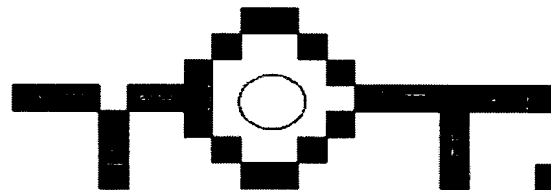
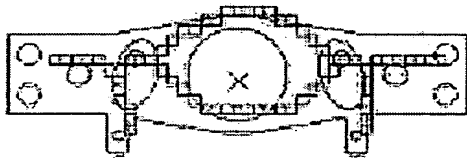


FIG. 37



3800

FIG. 38



3900

Node
Voxel
Edge
Loop

FIG. 39

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4000



```
• start()                // Find the Starting voxel
{
    - Find a terminal node
    - Else choose top:left:back most voxel
}
• march()
  - for each next voxel
  - {
      • findNeighbors()
      • If(nNeigh == Nil)    // nNeigh – Number of Neighbors
        - NODE; Terminate
      • If(nNeigh == NORMAL Neighbors)
        - Change voxel content to currentEntityID
        - Push voxel into current entity's stack
        - Iterate
      • If(nNeigh > NORMAL Neighbors) {
        - Check isNode() for all neighbors
        - Find the node and step into it
        - Push the current node to the Node stack
        - For all branch {
            march along()
        - }
      • findLoopEntities(){          // Simple Loops
        Trace back the previous nodes
        Add the corresponding entities to the loop
        - }
      • Pop node from the current node stack
      • iterate
  }
```

FIG. 40

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4100

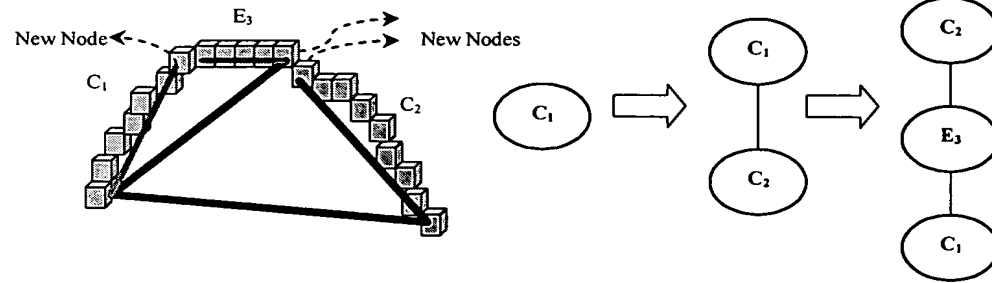


FIG. 41

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4200

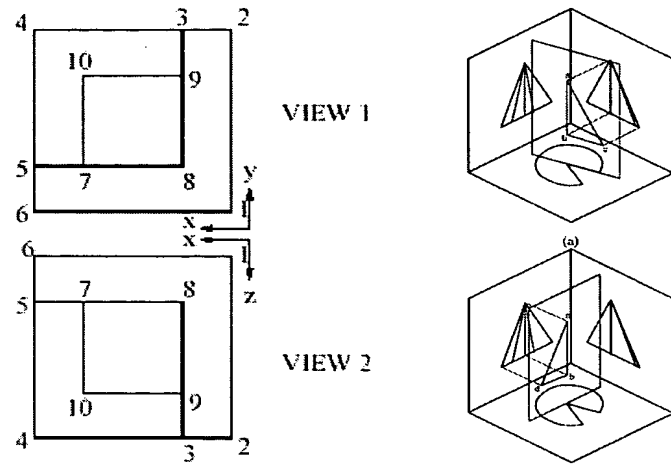


FIG. 42

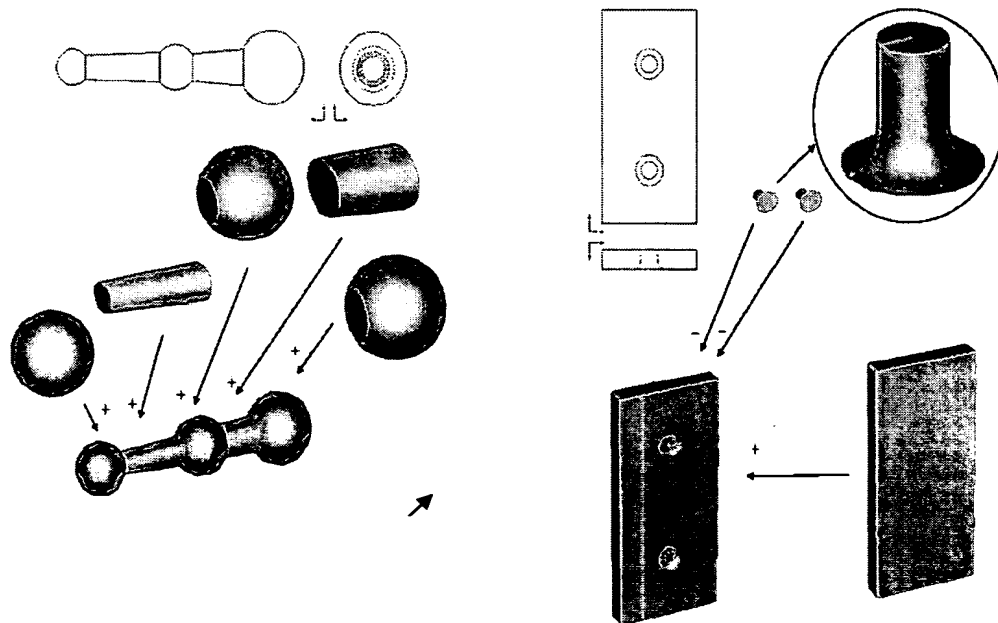


FIG. 43

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

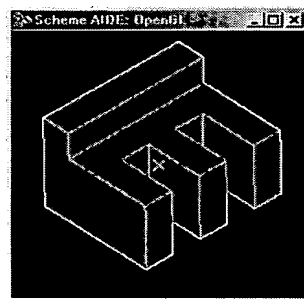
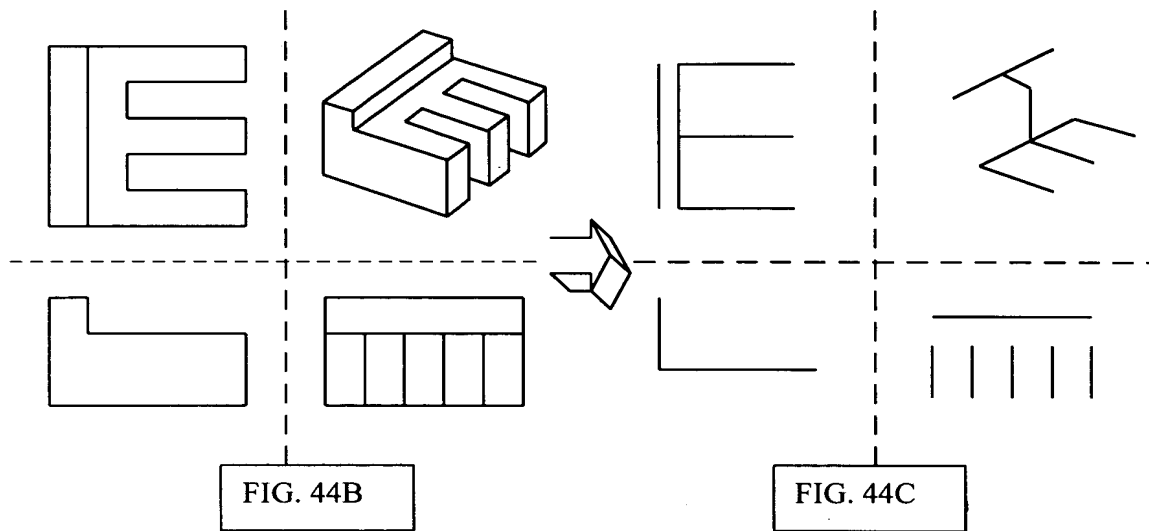
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4400



Actual 3D Model

Fig. 44A

FIG. 44

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4500

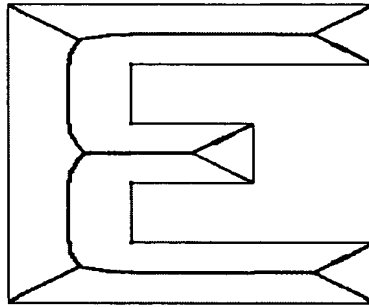


FIG. 45

4600

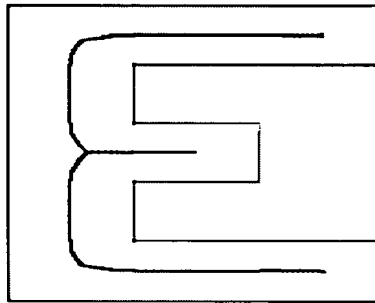


FIG. 46

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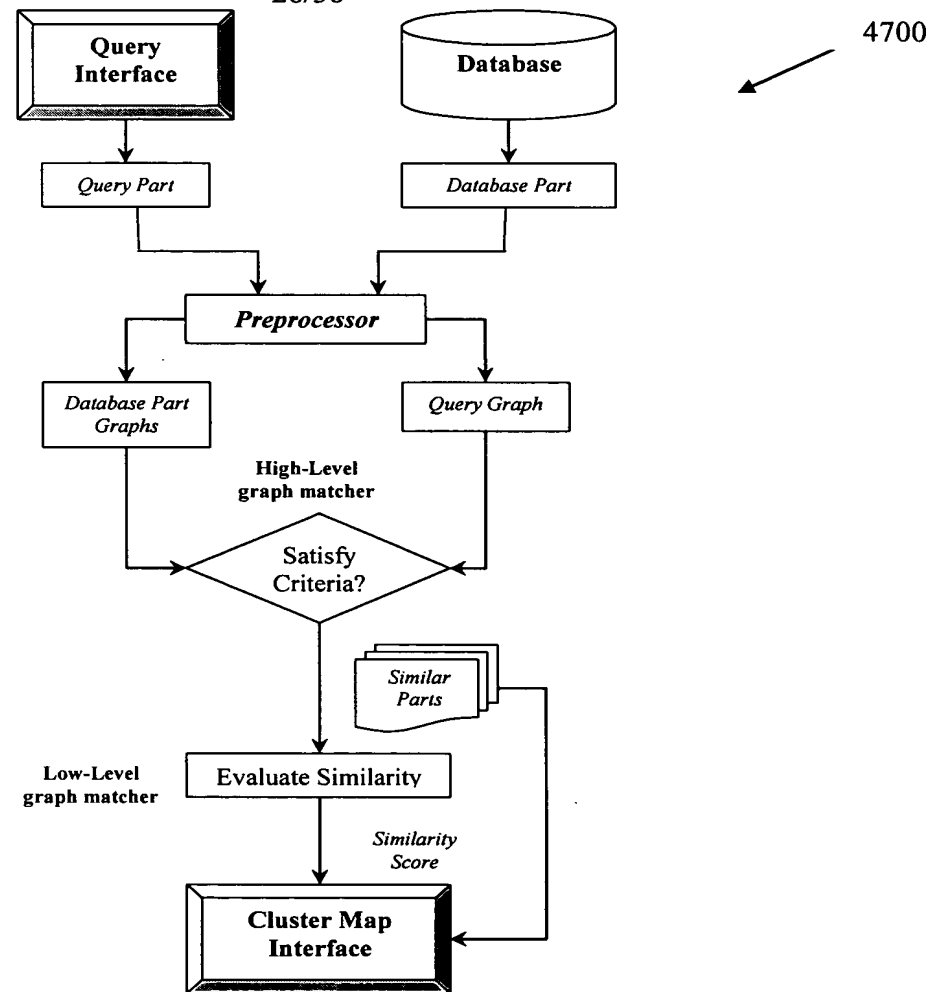


FIG. 47

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4800

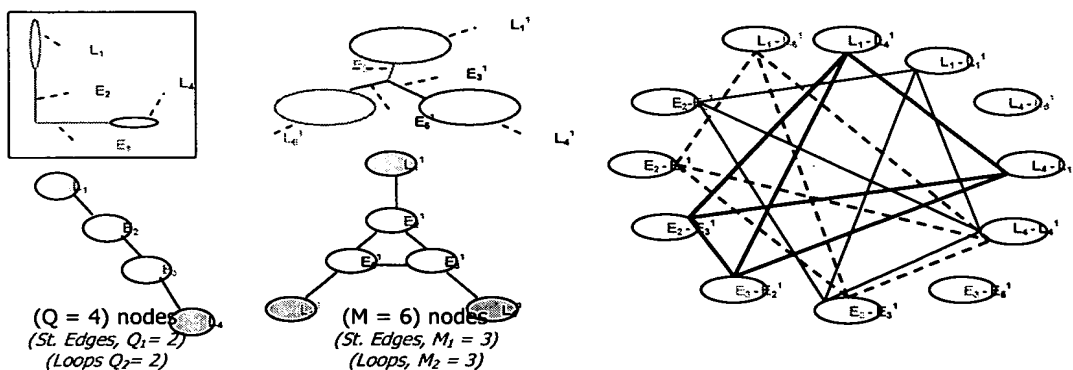


FIG. 48

4900

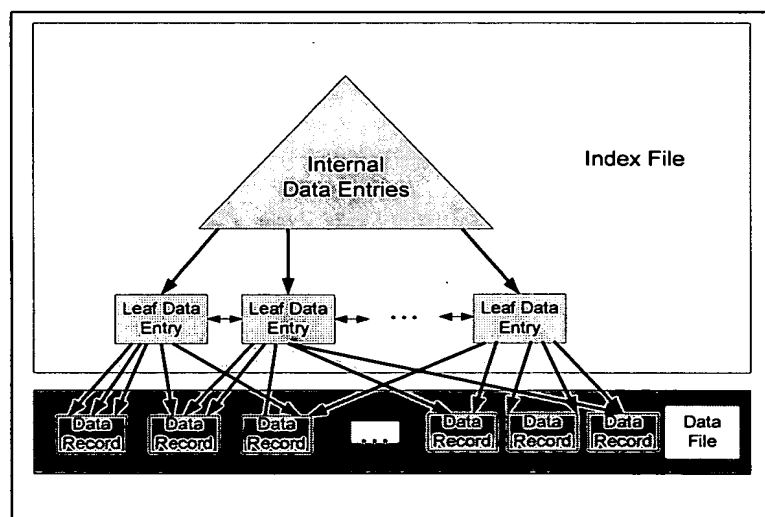


FIG. 49

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SEARCHES ON THREE DIMENSIONAL OBJECTS

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5000

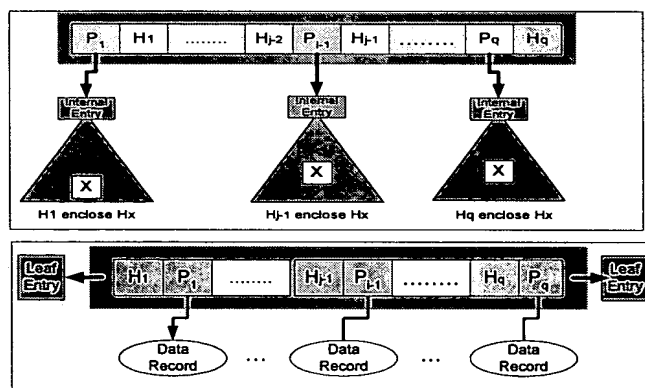


FIG. 50

5100

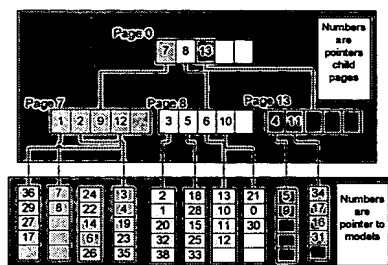


Figure 51A

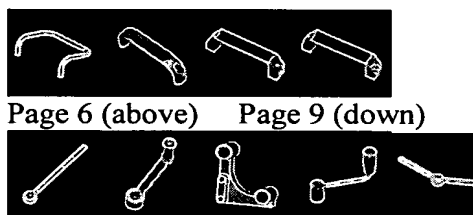


Figure 51B

FIGS. 51A and 51B

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

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5200

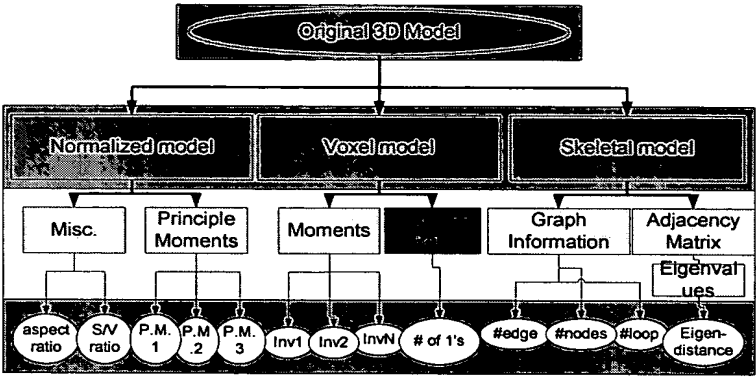


FIG. 52

5300

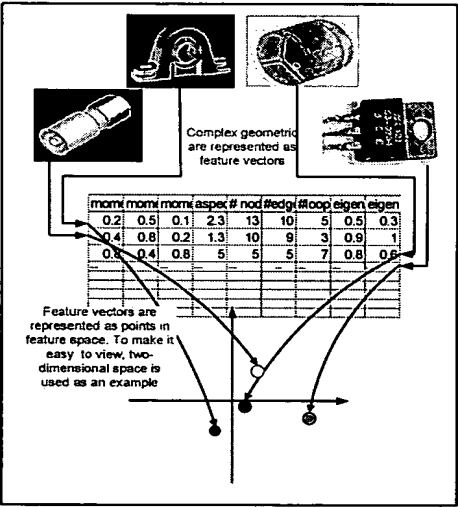


FIG. 53

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

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CLIENT REFERENCE NO.: P-02132.P1.US

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5400

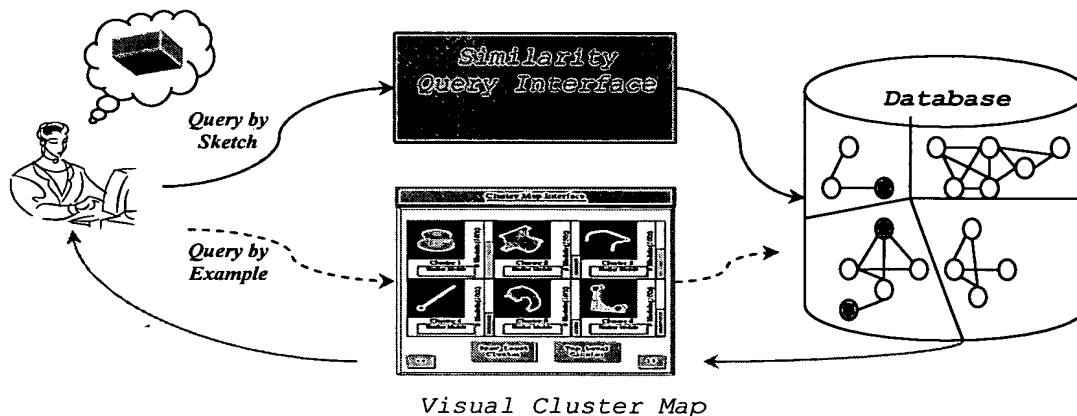
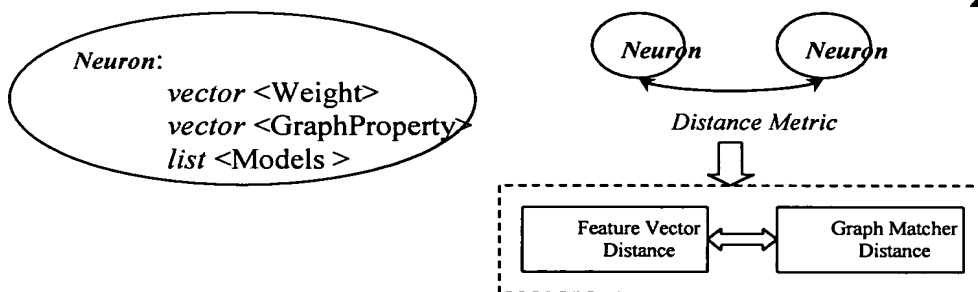


FIG. 54



5500

FIG. 55

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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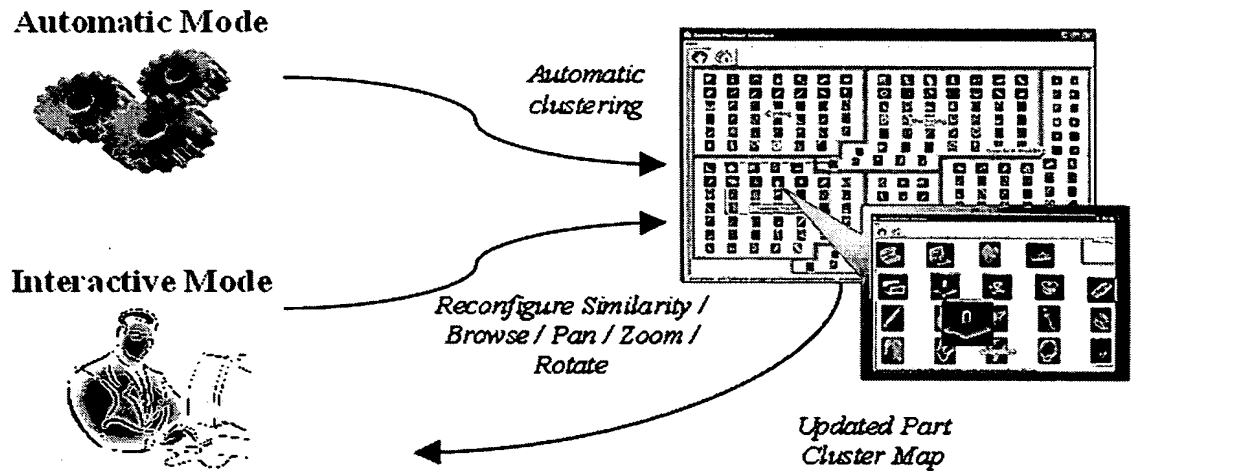


FIG. 56

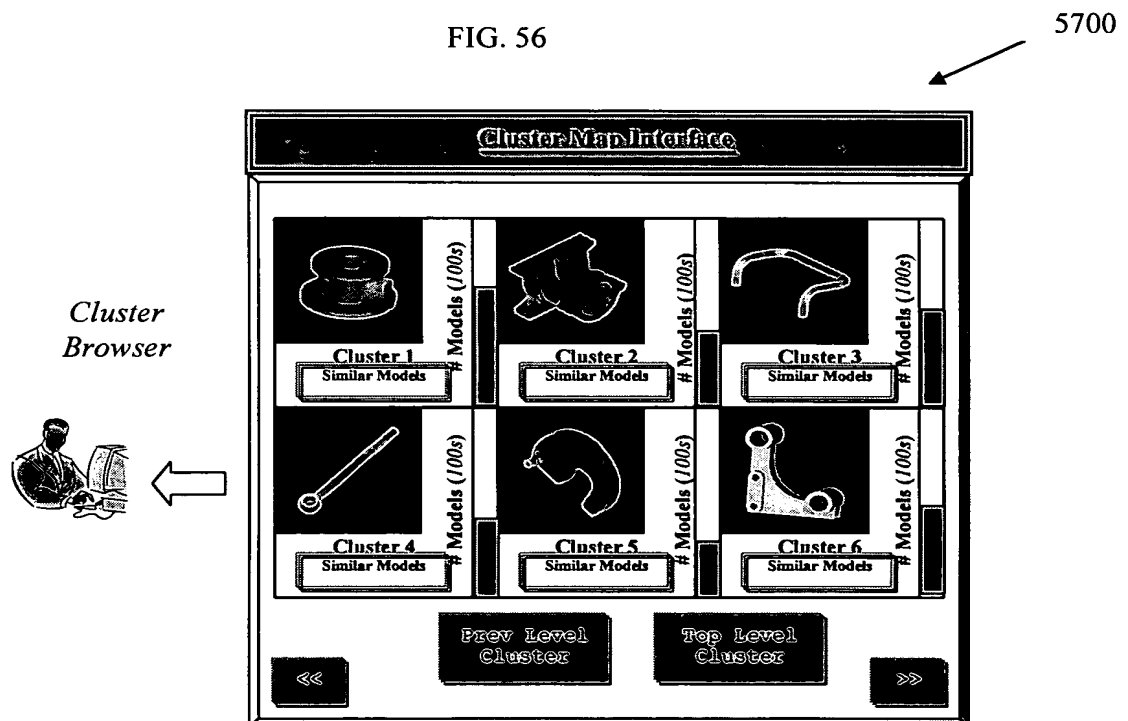


FIG. 57

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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5800

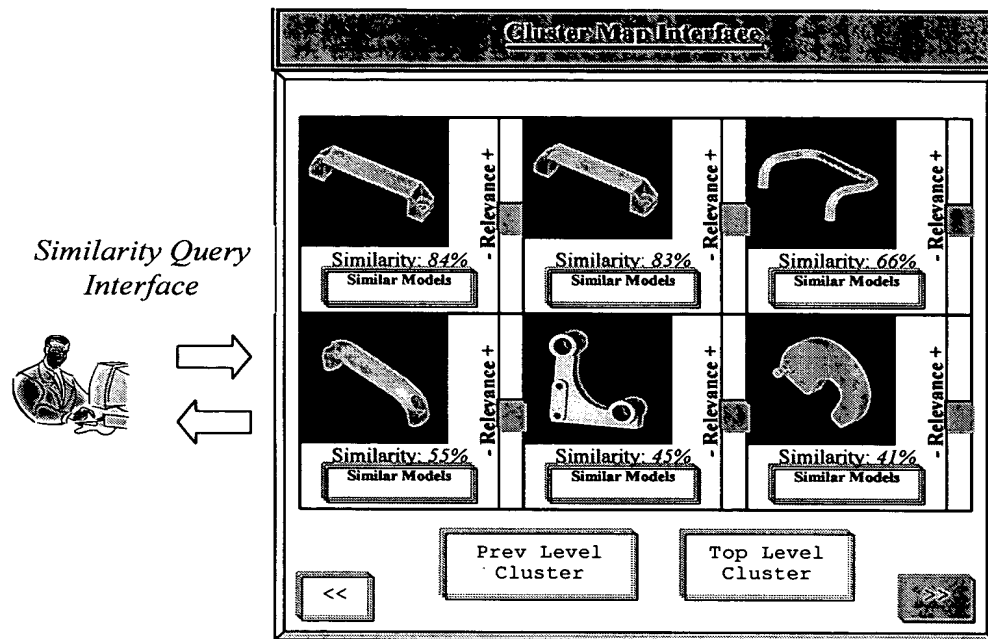


FIG. 58

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

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5900

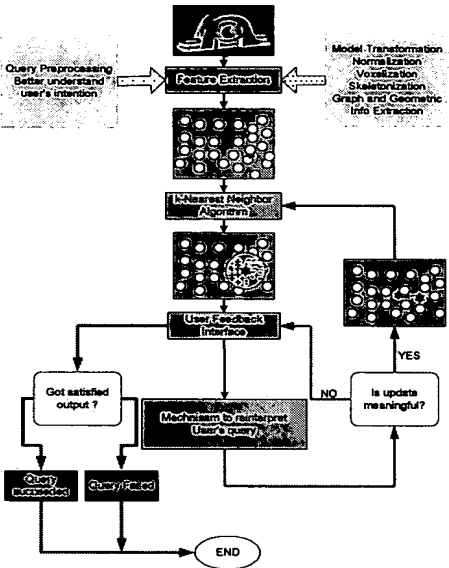


FIG. 59

6000

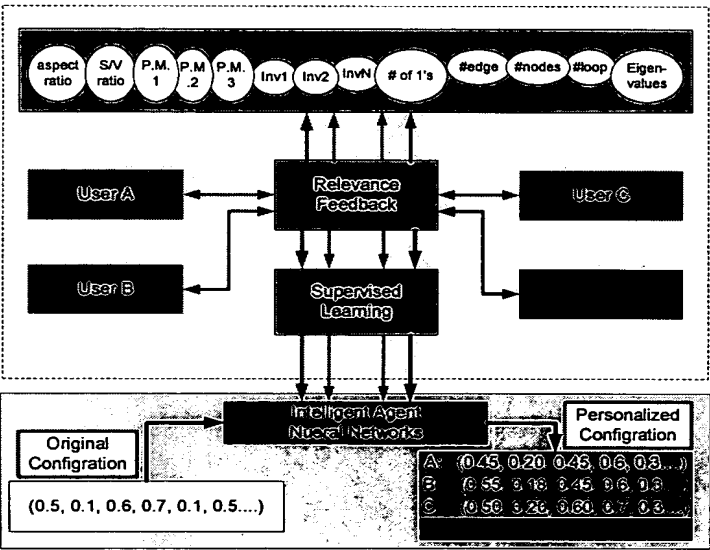


FIG. 60

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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6100

Database feature vector			Relevance Feedback	Query Vector		Reconfiguration
No.	F1	F2		F1	F2	
1	0.1	0.2		0.1	0.06	$W_1^{(1)} = W_1^{(0)}$
2	0.2	0.6		0.2	0.2	$W_2^{(1)} = 3 \times W_2^{(0)}$
3	0.3	0.4		0.3	0.13	
4	0.5	0.6		0.5	0.06	$W_1^{(1)} = W_1^{(0)}$
5	0.6	0.9		0.6	0.09	$W_2^{(1)} = 10 \times W_2^{(0)}$
6	0.7	1.0		0.7	0.10	
7	0.8	0.8				???
8	0.65	0.55				???

FIG. 61

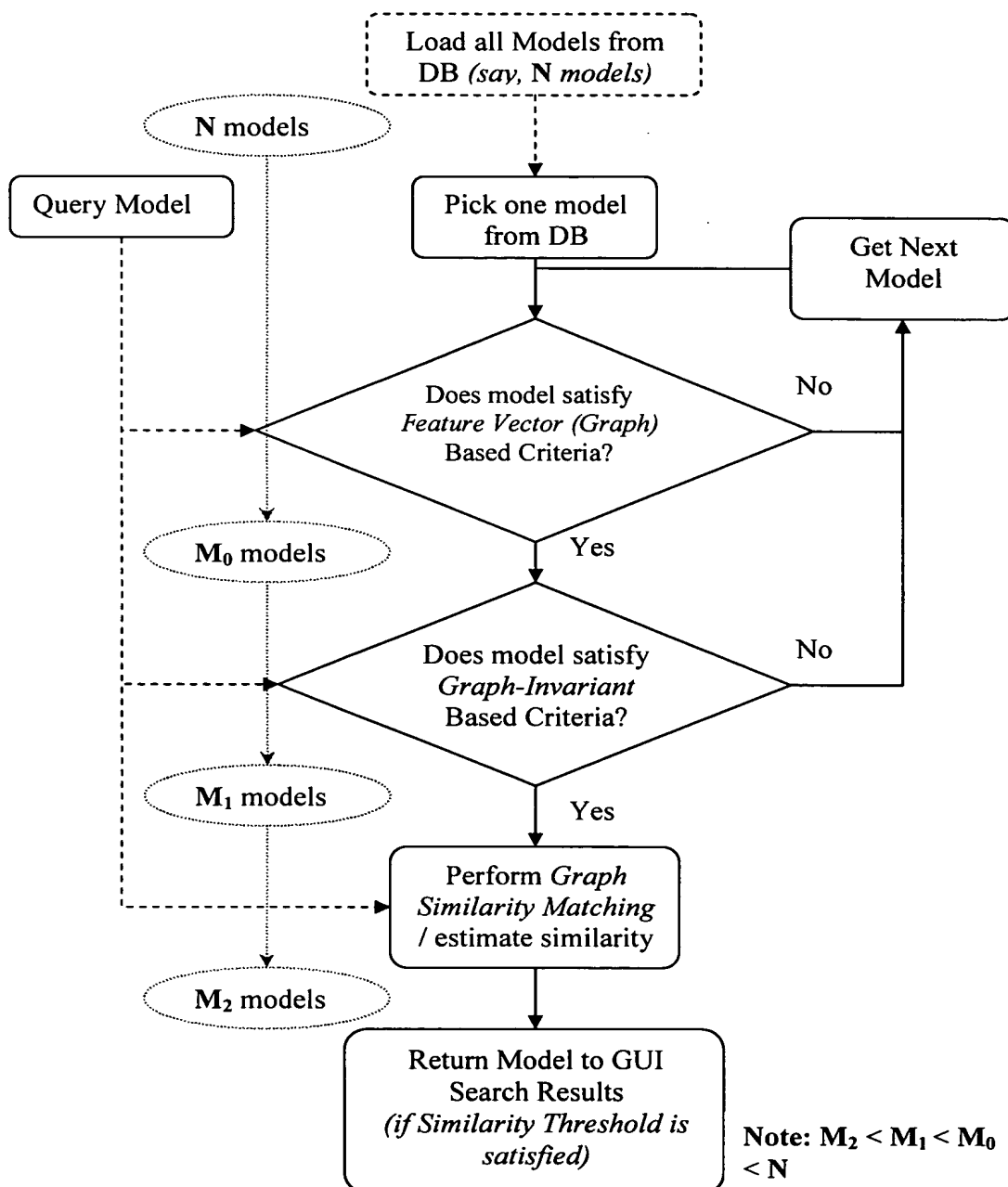


FIG. 62

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

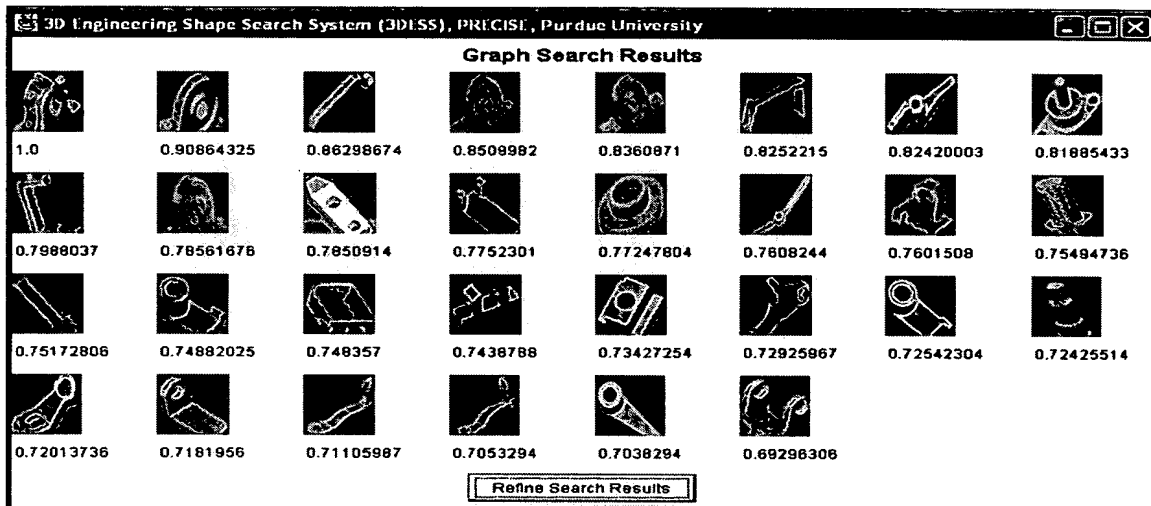
INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

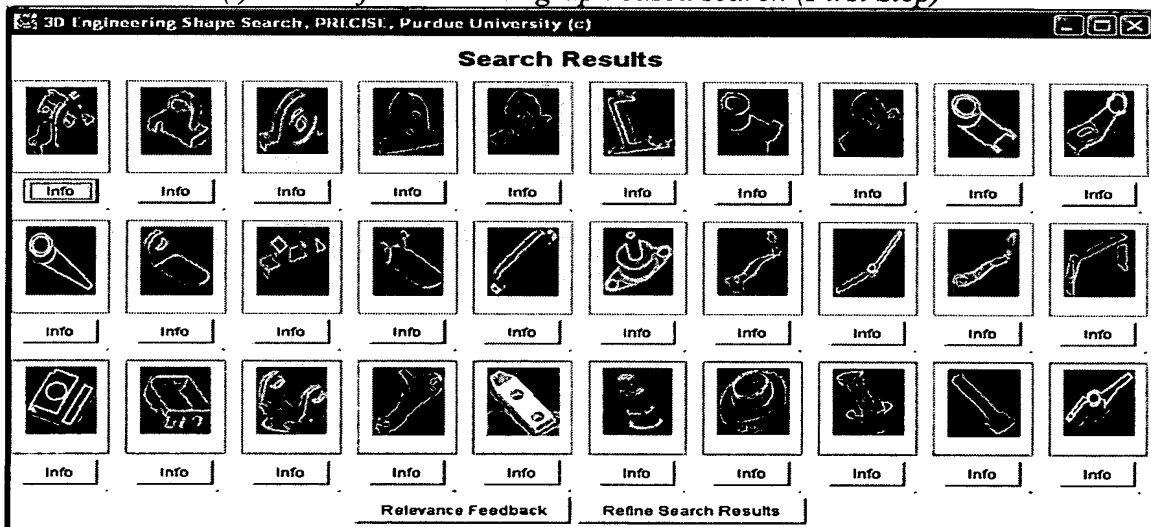
CLIENT REFERENCE NO.: P-02132.P1.US

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6300



(i) Results from skeletal graph based search (First Step)



(ii) Results after refining the query in (i) using moment invariants (Second Step)

FIG. 63

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